in FIGS. 5A and 7A. In contrast to this, the use of a projection optical system constituted by a reflecting/refracting optical system using a concave mirror and the like will provide advantageous effects in terms of aberrations and the like, especially as the wavelength of exposure light decreases. If this reflecting/refracting optical system is used, since the aberrations of a concave mirror or the like are reduced as the distance from the optical axis increases, the slit-like illumination area on the reticle 7 becomes an arcuated illumination area 81, as shown in FIG. 13A.

Assume that a width D of the illumination area 81 in the relative scanning direction is constant, and that the longitudinal direction, of the illumination area 81, which is perpendicular to the relative scanning direction is defined as the Y direction. In this case, the Y-direction illuminance distribution of the illumination area 81 is set to be trapezoidal, as shown in FIG. 13B. That is, in two side areas 81*a* and 81*b* of the illumination area 81 in the Y direction, the illuminances linearly decrease to 0. By setting such an illuminance distribution, the illuminance irregularity at the connection portion in a stitching operation can be reduced, similar to the second embodiment described above.

Consider a case where a regular hexagonal illumination area is set, as a modification of the second embodiment described above. The arrangement of this modification is the same as that of the second embodiment except for the shape of an illumination area.

In the modification, in the first and second wafer scanning operations, the wafer is set at the same X-direction position when a pulse laser source performs pulse emission. More specifically, as shown in FIG. 16A, the X-direction positions of an exposure point P9 which are set when pulse emission is performed in the first wafer scanning operation are defined as positions 8, and the X-direction positions of an exposure point P9 which are set when pulse emission is performed in the second wafer scanning operation are defined as positions 12. In this case, a main control system 23 controls the timing of pulse emission through a laser source control system 51 to make the positions 12 and 8 coincide with each other. As shown in FIG. 16A, there are five positions 8 inside an area 3*a*, and three positions 12 inside an area 3*b*. Therefore, with the two slit scanning exposure operations, energy corresponding to a total of eight pulses is radiated on the exposure point P9.

FIG. 16B shows a case where the pulse emission timings in the first and second scanning operations are shifted from those in the case shown in FIG. 16A in the X direction by ΔL/2. Referring to FIG. 16B, assume that the X-direction positions of an exposure point P9 which are set when pulse emission is performed in the first wafer scanning operation are defined as positions 10, and the X-direction positions of the exposure point P9 which are set when pulse emission is performed in the second wafer scanning operation are defined as positions 13. In this case, the wafer is also set at the same X-direction position when the pulse laser source performs pulse emission in the first and second wafer scanning operations. Since there are four positions 10 in an area 3*a*, and four positions 13 in an area 3*b*, energy corresponding to eight pulses is radiated on the exposure point P9 by the two slit scanning exposure operations. In general, according to this modification, energy corresponding to eight pulses is radiated on each exposure point in a connection portion 4 as well as an exposure point P0 in a non-connection portion, thereby preventing illuminance irregularity.

Furthermore, in the modification, the pulse emission timing is controlled such that a wafer is set at the same X direction position when the pulse laser source performs pulse emission in the first and second scanning operations. However, a wafer side. X stage 27 may be controlled.

In the second embodiment and its modification, a stitching operation using one reticle has been described. However, a plurality of reticles may be placed on the same reticle stage, and scanning exposure may be repeatedly performed while the reticles are interchanged with each other in a stitching operation. In addition, the reticle stage in the second embodiment and its modification may be constituted by a reticle side scanning stage and a reticle side fine adjustment stage, as in the case of the reticle stage system in the first embodiment.

The present invention is not limited to the first and second embodiments described above, and various changes and modifications can be made without departing from the scope and spirit of the invention.

What is claimed is:

1. An exposure apparatus for radiating exposure light on a predetermined illumination area on a mask on which a pattern to be transferred is formed, and exposing the pattern on a photosensitive substrate, comprising:

a scanning system for synchronously scanning the mask and the photosensitive substrate in a predetermined first direction of the illumination area while maintaining a predetermined speed ratio; and

an illumination condition setting portion for setting the illumination area to be rectangular, and letting a light intensity distribution of the illumination area in a second direction substantially perpendicular to the first direction have a trapezoidal shape so that a middle portion of the distribution exhibits a substantially constant light intensity, and two side portions of the distribution exhibit a gradually decreasing light intensity.

2. An apparatus according to claim 1, wherein said scanning system scans the mask and the photosensitive substrate at least twice in the first direction, and further comprising a substrate moving system for moving the photosensitive substrate in the second direction while first and second scanning operations with respect to the mask and the photosensitive substrate are performed by said scanning system.

3. An apparatus according to claim 2, further comprising a mask moving system for moving the mask in the second direction while first and second scanning operations with respect to the mask and the photosensitive substrate are performed by said scanning system.

4. An apparatus according to claim 2, further comprising:

storage portion for storing a relative positional difference between the mask and the photosensitive substrate when the mask and the photosensitive substrate are to be synchronously scanned in the first direction; and

a controller for controlling a position of at least of one of the mask and the photosensitive substrate such that the relative positional difference in the first scanning operation with respect to the mask and the photosensitive substrate coincides with that in the second scanning operation.

5. An apparatus according to claim 2 wherein said illumination condition setting portion determines a length M of each of the side portions, of the illumination area, in which the light intensity gradually decreases, in the second direction so as to establish

$$M=(n\cdot LP-LT)/(n+1)$$

where n is an integer of not less than one, LP is a length of

an illumination area on the mask in the second direction, and LT is a width of a pattern area, formed on the mask, in the second direction.

6. An apparatus according to claim 5, further comprising a projection optical system for projecting an image of a pattern of the mask, irradiated with the exposure light, onto the photosensitive substrate at a projecting magnification β, and wherein a moving amount of the photosensitive substrate moved by said substrate moving system in the second direction is defined as

$$\pi \cdot (LP - M)/\beta$$

7. A projection exposure apparatus comprising:

a pulse light source for pulse-emitting exposure light;

an illumination optical system for illuminating a predetermined illumination area on a mask, on which a pattern to be transferred is formed, with the exposure light;

a projection optical system for projecting an image of the pattern, irradiated with the exposure light, onto a photosensitive substrate;

a scanning system for synchronously scanning the mask and the photosensitive substrate at least twice in a predetermined first direction of the illumination area while maintaining a predetermined speed ratio;

a substrate moving system for moving the photosensitive substrate in a second direction substantially perpendicular to the first direction while first and second scanning operations with respect to the mask and the photosensitive substrate are performed by said scanning system; and

a controller for controlling at least one of said pulse light source and said scanning system such that a position of the photosensitive substrate in the first direction at the time when said pulse light source performs pulse emission, in the first scanning operation with respect to the photosensitive substrate and the mask coincides with that in the second scanning operation.

8. An apparatus according to claim 7, wherein said controller includes a position storage portion for detecting a position of the photosensitive substrate in the first direction when said pulse light source performs pulse emission, and storing data indicating the position, and controls one of said pulse light source and said synchronous scanning means on the basis of the stored data indicating the position of the photosensitive substrate.

9. A scanning exposure apparatus comprising:

a scanning system for synchronously scanning a mask and a photosensitive substrate for scanning exposure; and

an adjusting system for moving the mask to decrease a positional deviation between the mask and the substrate, independently of scanning of the mask which is performed by said scanning system, during the scanning exposure.

10. An apparatus according to claim 9, further comprising:

a projection optical system for projecting a pattern image of the mask onto the substrate; and wherein

said scanning system includes a mask stage for scanning the mask in a direction perpendicular to an optical axis of said projection optical system and a substrate stage for scanning the substrate in the direction perpendicular to the optical axis, and causes the mask stage and the substrate stage to scan at a speed ratio corresponding to a projecting magnification of said projection optical system.

11. An apparatus according to claim 10, wherein

said adjusting system includes a finely movable stage for relatively moving the mask on said mask stage and a driving member for finely driving said finely movable stage in the direction perpendicular to said optical axis.

12. An apparatus according to claim 11, further comprising:

a first measuring system for measuring a position of the mask within a plane perpendicular to said optical axis; and

a second measuring system for measuring a position of the substrate within a plane perpendicular to said optical axis, and wherein

said adjusting system includes a controller for controlling the driving member in accordance with signals from said first and second measuring systems.

13. An apparatus according to claim 12, wherein

said first measuring system includes a rotational angle detecting device for detecting a rotational angle of the mask within the plane perpendicular to said optical axis.

14. An apparatus according to claim 13, wherein

said finely movable stage includes a mirror having a reflecting surface substantially perpendicular to said plane, and

said first measuring system includes an interferometer for radiating a light beam onto said reflecting surface and receiving the light beam reflected by said reflecting surface.

15. A scanning exposure apparatus for projecting a pattern image of a mask onto a sensitive plate through a projection optical system in a scanning manner, the exposure apparatus comprising:

(a) a plate stage for scanning the plate in at least one-dimensional direction under said projection optical system for the scanning exposure;

(b) a first mask stage for scanning the mask in at least said one-dimensional direction above said projection optical system for the scanning exposure;

(c) a second mask stage for finely moving the mask on said first mask stage in each of translational and rotational directions;

(d) a first driving system for synchronously driving said plate stage and said first mask stage with a predetermined velocity ratio for the scanning exposure;

(e) a detecting system for detecting a positional deviation amount between the mask and the plate in a real time manner during the scanning exposure; and

(f) a second driving system for driving said second mask stage to decrease the detected deviation amount during the scanning exposure.

16. The scanning exposure apparatus according to claim 15, wherein said detecting system includes a first measuring unit to detect a relative translational deviation amount between the mask and the plate and a second measuring unit to detect a relative rotational deviation amount between the mask and the plate.

17. The scanning exposure apparatus according to claim 16, wherein said second drive system includes a first actuator unit for finely moving said second mask stage in said one-dimensional scanning direction and in a cross direction of said scanning direction based on said translational deviation amount.

18. The scanning exposure apparatus according to claim 16, wherein said second drive system includes a second

actuator unit for finely rotating said second mask stage about a predetermined point on the mask based on said rotational deviation amount.

19. The scanning exposure apparatus according to claim 18, wherein said predetermined point on the mask is changed in said one-dimensional scanning direction according to the scanning position of the mask.

20. The scanning exposure apparatus according to claim 16, wherein said first and second measuring units include a mask side interferometer system for measuring a coordinate position and a rotational angle of the mask and a plate side interferometer system for measuring a coordinate position and a rotational angle of the plate.

21. The scanning exposure apparatus according to claim 15, wherein each of said plate stage and said first mask stage is linearly movable in said one-dimensional scanning direction by restraining of respective linear air-guide structures.

22. The scanning exposure apparatus according to claim 21, wherein said first driving system includes a mask side linear motor for driving said first mask stage guided by the corresponding linear air-guide structure and a plate side linear motor for driving said plate stage guided by the corresponding linear air-guide structure.

23. A scanning exposure apparatus for projecting a pattern image of a mask onto a sensitive plate through a projection optical system in a scanning manner, the exposure apparatus comprising:

(a) a plate stage for moving the plate in at least one-dimensional direction under said projection optical system which has an imaging reduction ratio $1/\beta$;

(b) a first mask stage for moving the mask in at least said one-dimensional direction above said projection optical system;

(c) a second mask stage for finely moving the mask on said first mask stage in each of translational and rotational directions;

(d) an illuminating system for irradiating the mask with a radiation having a slit shaped distribution elongated perpendicular to said one-dimensional direction on the mask in order to project a slit shaped partial pattern image of the mask onto the plate through said projection optical system;

(e) a first driving system for synchronously, relatively driving said plate stage and first mask stage with a velocity ratio B for the scanning exposure of the plate by said slit shaped partial pattern image of the mask;

(f) a detecting system for detecting a deviation amount from an ideal positional relation of the mask and the plate occurring at a term of the scanning exposure; and

(g) a second driving system for driving said second mask stage to correct the deviation during the scanning exposure when said detected deviation amount is out of a predetermined tolerance.

24. The scanning exposure apparatus according to claim 23, wherein said detecting system includes a first measuring system to detect a translational deviation amount from said ideal positional relation of the mask and the plate and a second measuring system to detect a rotational deviation amount from said ideal positional relation of the mask and the plate.

25. The scanning exposure apparatus according to claim 24, wherein said second drive system includes a first actuator system for finely moving said second mask stage in said one-dimensional scanning direction and a cross direction thereof based on said translational deviation amount.

26. The scanning exposure apparatus according to claim 24, wherein said second drive system includes a second actuator system for finely rotating said second mask stage about a predetermined point on the mask based on said rotational deviation amount.

27. The scanning exposure apparatus according to claim 26, wherein said predetermined point on the mask is changed in said one-dimensional scanning direction according to the scanning position of the mask.

28. The scanning exposure apparatus according to claim 23, wherein said first driving system includes a mask side linear motor for driving said first mask stage supported by an air-guide structure and a plate side linear motor for driving said plate stage supported by an air-guide structure.

29. A scanning exposure apparatus for projecting a pattern image of a mask onto a sensitive plate through a projection system having a predetermined magnification ratio in a scanning manner, the apparatus comprising:

(a) a scanning system for synchronously, relatively scanning the mask and the plate with respect to a projection field of said projection system at a velocity ratio corresponding to said magnification ratio during the scanning exposure;

(b) a finely movable stage provided on said scanning system for finely moving the mask relative to said scanning system in each of translational and rotational directions;

(c) a detecting system for detecting a positional deviation amount between an ideal positional relation and an actual positional relation of the mask and the plate during the scanning exposure; and

(d) a control system for driving said finely movable stage based on said detected deviation amount in order to decrease the positional deviation of the mask and the plate.

30. A scanning exposure method in which a pattern area of a mask is transferred onto a sensitive plate through a projection optical system in a scanning manner, the method comprising the steps of:

(a) irradiating the mask with a radiation having a slit shaped intensity distribution in order to project a slit image portion of said pattern area of the mask toward the plate through said projection optical system;

(b) synchrouously scanning each of the mask and the plate relative to said projection optical system in a scanning direction perpendicular to a longitudinal direction of said slit image portion at a predetermined velocity ratio by using a scanning mechanism for the scanning exposure;

(c) detecting a deviation value between an ideal positional relation and an actual positional relation of the mask and the plate at a term of the scanning exposure; and

(d) correcting a position of the mask determined by said scanning mechanism so as to decrease said detected deviation value by using a fine moving mechanism provided on said scanning mechanism at the term of the scanning exposure.

31. The scanning exposure method according to claim 30, wherein said detecting step includes detecting a relative rotational deviation between the mask and the plate and said fine moving mechanism finely rotates the mask to decrease said rotational deviation.

32. The scanning exposure method according to claim 31, wherein said relative rotational deviation is detected by using a mask side interferometer system and a plate side interferometer system.

33. A scanning exposure method in which a pattern area

of a mask is transferred onto a sensitive plate through a projection system in a scanning manner, the method comprising the steps of:

(a) irradiating the mask with a radiation in order to project an image portion of said pattern area of the mask onto the plate through said projection system;

(b) synchronously scanning each of the mask and the plate relative to said projection system in a scanning direction at a predetermined velocity ratio by using a scanning mechanism for the scanning exposure;

(c) detecting a deviation between an ideal positional relation and an actual positional relation of the mask and the plate at a term of the scanning exposure; and

(d) correcting a position of the mask determined by said scanning mechanism for decreasing said detected deviation by using a fine moving mechanism provided on said scanning mechanism at the term of the scanning exposure.

34. A scanning exposure apparatus for projecting a pattern image of a mask onto a sensitive plate through a projection system in a scanning manner, the exposure apparatus comprising:

(a) a plate stage for moving the plate under said projection system in an X direction for the scanning exposure and in a Y direction perpendicular to the X direction;

(b) a first mask stage for moving the mask in the X direction for the scanning exposure above said projection system;

(c) a second mask stage for finely moving the mask on said first mask stage in each of translational and rotational directions;

(d) first driving means for synchronously driving each of said plate stage and said first mask stage with a predetermined velocity ratio in the X direction during the scanning exposure; and

(e) second driving means for driving said plate stage and said second mask stage to maintain a translational relation of the mask and plate in the Y direction and for driving said second mask stage to maintain a relative rotational relation of the mask and the plate, during the scanning exposure.

* * * * *

--35. A scanning exposure method in which in synchronism with movement of a first object formed with a predetermined pattern a second object is moved, thereby exposing sequentially a plurality of defined regions on said second object, comprising:

effecting an exposure onto one of the plurality of the defined regions on said second object while moving said second object in a predetermined direction, and

after finishing the exposure, moving said second object in a direction intersecting with said predetermined direction while moving said second object in said predetermined direction.--

--36. A scanning exposure method in which in synchronism with movement of a first object formed with a predetermined pattern a second object is moved, thereby exposing sequentially a plurality of defined regions on said second object, comprising:

effecting an exposure onto one of the plurality of the defined regions on said second object while moving said second object in a predetermined direction, and

after finishing the exposure, accelerating said second object in a direction intersecting with said predetermined direction while decelerating said second object in said predetermined direction.--

--37. A scanning exposure method in which in synchronism with movement of a first object formed with a

predetermined pattern a second object is moved, thereby exposing sequentially a plurality of defined regions on said second object, comprising:

a first step of effecting an exposure onto one of the plurality of defined regions on said second object while moving said second object in a predetermined direction,

a second step of decelerating said second object in said predetermined direction after finishing the exposure,

a third step of accelerating said second object in a reverse direction to said predetermined direction after said second step, and

a fourth step of accelerating and decelerating said second object in a direction intersecting with said predetermined direction during said second step and said third step.--

--38. A scanning exposure method in which in synchronism with movement of a first object formed with a predetermined pattern a second object is moved, thereby exposing sequentially a plurality of defined regions on said second object, comprising:

effecting an exposure onto one of the plurality of defined regions on said second object while moving said second object in a predetermined direction, and

after finishing the exposure, moving said second object in a direction inclined with respect to said predetermined direction.--

--39. A scanning exposure method in which in synchronism with movement of a first object formed with a predetermined pattern a second object is moved, thereby exposing sequentially a plurality of defined regions on said second object, comprising:

effecting an exposure onto one of the plurality of the defined regions on said second object while moving said first object in a first direction and moving said second object in a second direction corresponding to said first direction, and

after finishing the exposure, moving said second object in a direction inclined with respect to said second direction while decelerating said first object in said first direction.--

--40. A scanning exposure method in which in synchronism with movement of a first object formed with a predetermined pattern a second object is moved, thereby exposing sequentially a plurality of defined regions on said second object, comprising:

a first step of effecting an exposure onto one of the plurality of defined regions on said second object while moving said first object in a first direction and moving said second object in a second direction corresponding to said first direction, and

a second step of decelerating said second object in said second direction after finishing the first step,

a third step of accelerating said second object in a reverse direction to said second direction after said second step, and

a fourth step of decelerating said first object and setting said first object to a reference position during said second step and said third step.--

--41. A scanning exposure method in which in synchronism with movement of a first object formed with a predetermined pattern a second object is moved, thereby exposing sequentially a plurality of defined regions on said second object, comprising:

effecting an exposure onto one of the plurality of defined regions on said second object while moving said second object in a predetermined direction, and

after finishing the exposure, starting accelerating said second object in a reverse direction to said predetermined direction for preparing a scanning exposure onto a next defined region while moving said second object in a direction intersecting with said predetermined direction.--